

# Drag

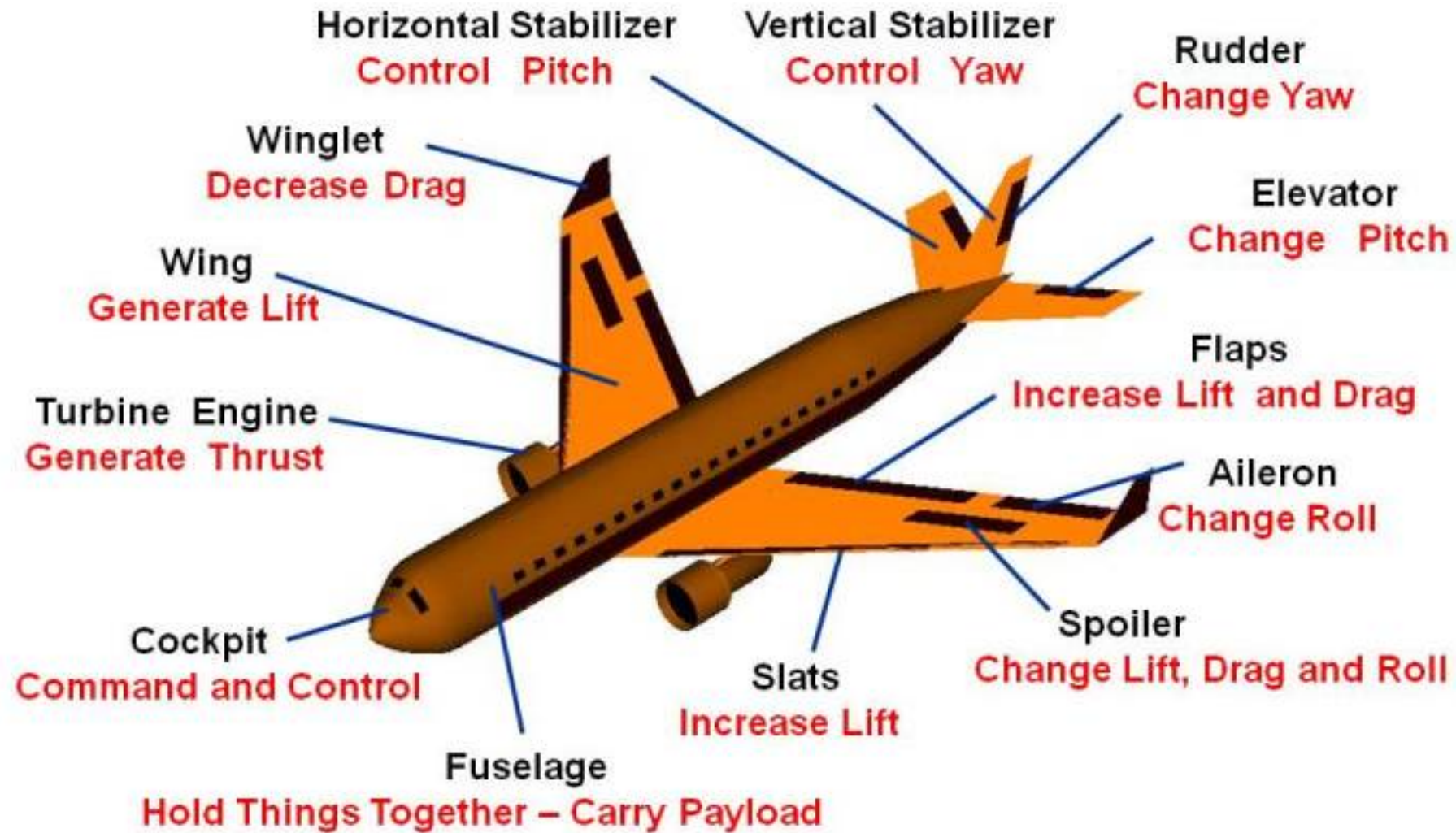


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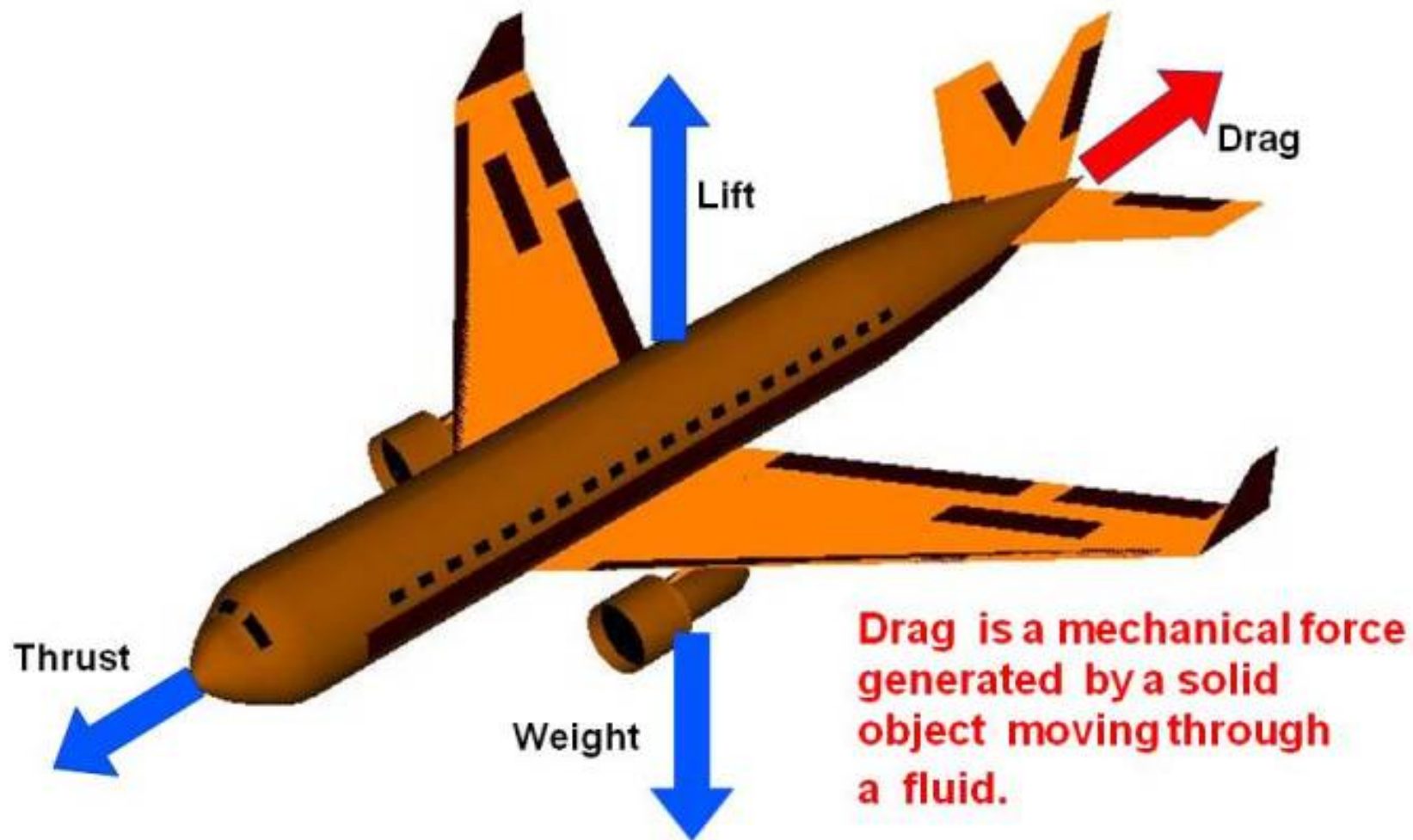


# Airplane Parts *and Function*





# What is Drag ?

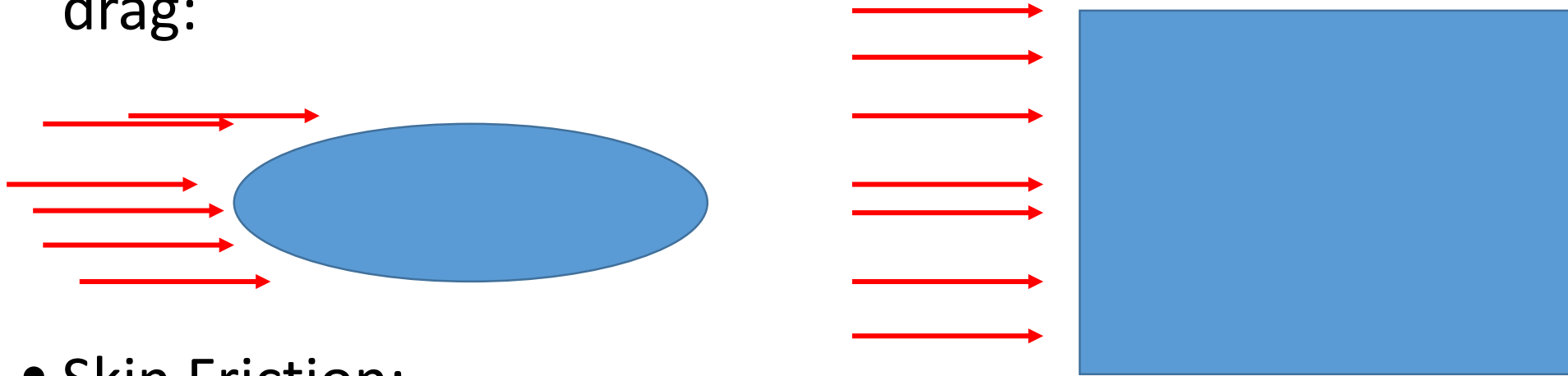


# Factors Affecting Drag

- Shape and Size
- Velocity and Inclination to Flow
- Mass, Viscosity, and Compressibility of air

# Factors Affecting Drag: Size and Shape

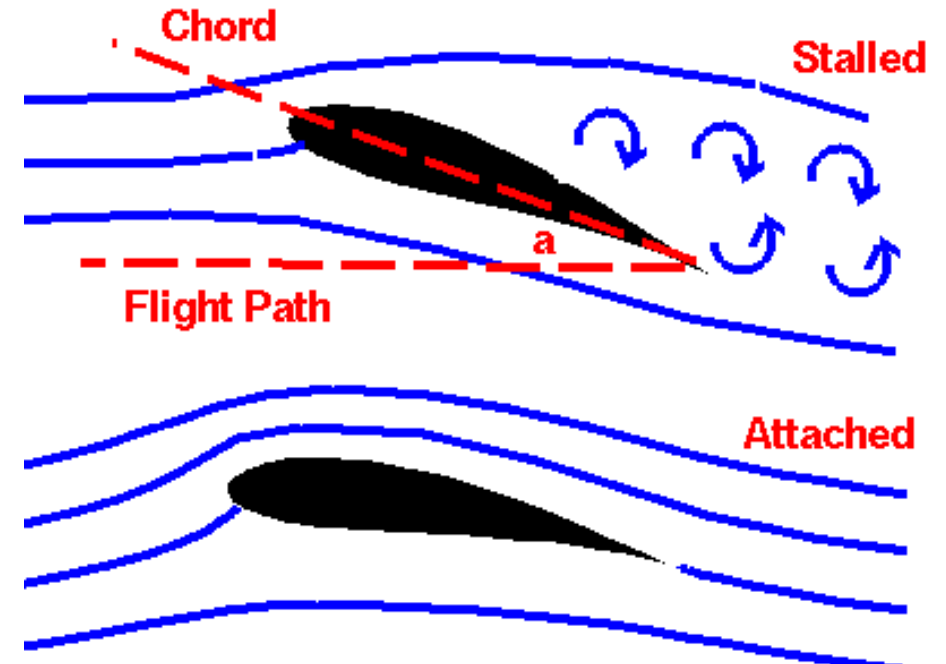
- The cross-sectional shape on an object determines the form of drag:



- Skin Friction:
  - the surface “roughness” smooth = less drag
  - rough = more drag

# Factors Affecting Drag: Velocity and Inclination

- Drag depends on **relative velocity** between object and air
- Inclination:
  - Small angles: smaller drag
  - Greater angles: greater drag
- Speed of Sound: produces shock waves and create additional **wave drag**
- Boundary Layers: also form and contribute to skin friction



# Factors Affecting Drag: Mass, Viscosity, and Compressibility of air

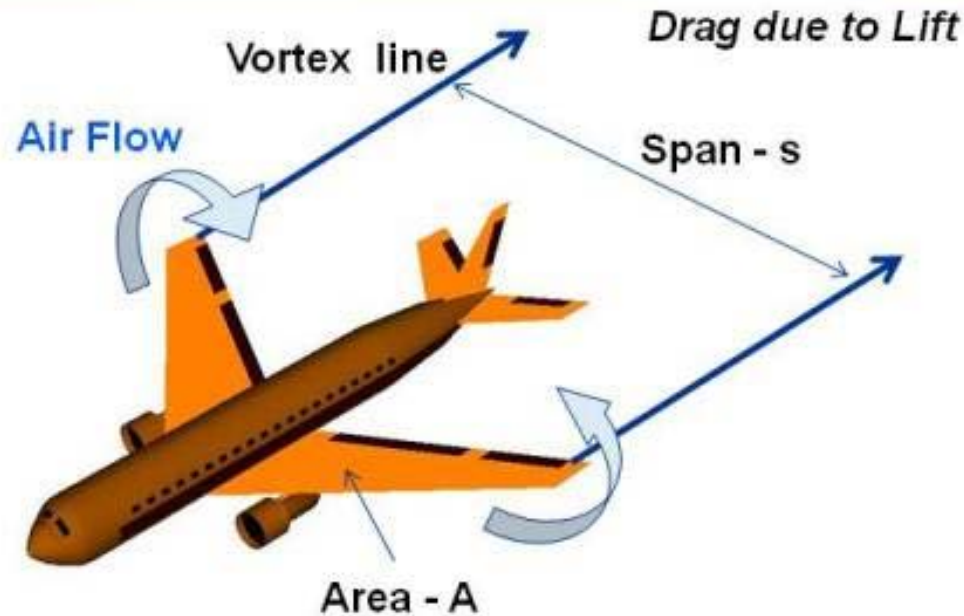
- Mass: amount of air flowing pass aircraft
- Viscosity: “stickiness” of air (Reynold’s)
- Compressibility: “springiness” of air (Mach)

# Induced Drag

National Aeronautics and Space Administration



## *Induced Drag Coefficient*



Pressure difference from top to bottom of the wing causes spillage around the wing tips.

Downwash from the tips induces local angle of attack with additional drag component on a finite wing.





# The Drag Equation

Glenn  
Research  
Center



$$D = C_d \times \frac{\rho \times V^2 \times A}{2}$$

Drag = coefficient x density x velocity squared x reference area  
two

Coefficient **C<sub>d</sub>** contains all the complex dependencies  
and is usually determined experimentally.

Choice of reference area **A** affects the value of **C<sub>d</sub>**.

# Flight: Review

- Show the video found at:

[http://www.youtube.com/watch?feature=player\\_embedded&v=5ltjFEei3Al#!](http://www.youtube.com/watch?feature=player_embedded&v=5ltjFEei3Al#!)